

Claims

What is claimed is:

1. An apparatus comprising:
a thread-forming fastener including a head for
5 engagement by a tool for applying a torque to the fastener,
and a body portion extending from the head and including
thread-forming portions; and
an ultrasonic transducer coupled with the
fastener, for making ultrasonic load measurements in
10 the fastener.
2. The apparatus of claim 1 wherein the
ultrasonic transducer is coupled with the head of the
fastener.
3. The apparatus of claim 1 wherein the
15 ultrasonic transducer is permanently attached to the
fastener.
4. The apparatus of claim 3 wherein the
ultrasonic transducer is comprised of a piezoelectric
polymer film permanently attached to the head of the
20 fastener.
5. The apparatus of claim 3 wherein the
ultrasonic transducer is comprised of an oriented
piezoelectric thin film, vapor deposited directly on
the head of the fastener.
- 25 6. The apparatus of claim 3 wherein the
ultrasonic transducer is chemically grafted on the head
of the fastener.

7. The apparatus of claim 1 wherein the ultrasonic transducer is temporarily attached to the fastener.

5 8. The apparatus of claim 1 wherein the ultrasonic transducer further includes an information storage medium applied to the ultrasonic transducer, wherein the information storage medium includes markings corresponding to data associated with the fastener.

10 9. The apparatus of claim 8 wherein the information storage medium is a bar code applied to the ultrasonic transducer.

10. A method of making a load indicating, thread-forming fastener, comprising the steps of:
providing a fastener having a first end including
15 a surface for receiving an ultrasonic transducer, for making ultrasonic load measurements in the fastener, a shank extending from the first end and including thread-forming portions for tapping a hole, and a second end, opposite the first end and including a surface for reflecting an
20 ultrasonic wave back to the first end; and
attaching an ultrasonic transducer to the first end of the fastener.

11. The method of claim 10 which further includes the step of attaching the ultrasonic transducer to a head
25 associated with the first end of the thread forming fastener, for engagement by a tool for applying a torque to the fastener.

12. The method of claim 10 which further includes the step of permanently attaching the ultrasonic transducer
30 to the fastener.

13. The method of claim 12 which further includes the step of permanently attaching an ultrasonic transducer comprised of a piezoelectric polymer film to the first end of the fastener.

5 14. The method of claim 12 which further includes the step of vapor depositing an ultrasonic transducer comprised of an oriented piezoelectric thin film directly onto the first end of the fastener.

10 15. The method of claim 12 which further includes the step of chemically grafting an ultrasonic transducer onto the first end of the fastener.

16. The method of claim 10 which further includes the step of temporarily attaching the ultrasonic transducer to the fastener.

15 17. The method of claim 10 which further includes the step of applying an information storage medium to the ultrasonic transducer, wherein the information storage medium includes markings corresponding to data associated with the fastener.

20 18. The method of claim 17 which further includes the step of applying a bar code to the ultrasonic transducer.

19. A method of measuring a load in a fastener, comprising the steps of:

25 providing a thread-forming fastener including a head for engagement by a tool for applying a torque to the fastener, and a body portion extending from the head and including thread-forming portions;

30 coupling an ultrasonic transducer with the fastener, for making ultrasonic load measurements in the fastener;

electrically connecting an apparatus to the ultrasonic transducer for supplying signals to the ultrasonic transducer and for receiving signals from the ultrasonic transducer;

5 monitoring the signals received from the ultrasonic transducer, providing an accurate measurement indicative of the load in the fastener; and

 adjusting the measurement indicative of the load to compensate for effects of heating of the fastener
10 resulting from forming a thread in a mating component during installation.

20. The method of claim 19 which further includes the step of imparting torque to the fastener and removing torque from the fastener in response to the measurement of
15 the load in the fastener.

21. The method of claim 19 which further includes the step of determining a zero-load ultrasonic measurement, using the measurement indicative of the load in the fastener.

22. The method of claim 21 which further includes
20 the step of measuring a torque in conjunction with the measurement indicative of the load in the fastener to determine the zero-load ultrasonic measurement.

23. The method of claim 21 which further includes the step of measuring an angle of rotation of the fastener
25 in conjunction with the measurement indicative of the load in the fastener to determine the zero-load ultrasonic measurement.

24. The method of claim 21 which further includes the step of measuring time in conjunction with the
30 measurement indicative of the load in the fastener to determine the zero-load ultrasonic measurement.

25. The method of claim 21 which further includes the step of taking measurements for determining the zero-load ultrasonic measurement prior to a load-inducing stage of the installation.

5 26. The method of claim 21 which further includes the step of taking measurements for determining the zero-load ultrasonic measurement during a load-inducing stage of the installation.

10 27. The method of claim 19 which further includes the step of placing markings on the ultrasonic transducer corresponding to data associated with the fastener.

28. The method of claim 27 which further includes the step of marking a bar code on the ultrasonic transducer.

15 29. A method of measuring a load in a fastener, comprising the steps of:

 providing a thread-locking fastener assembly including a bolt having a head for engagement by a tool for applying a torque to the fastener assembly and a body portion extending from the head, and a nut for cooperating with the body portion of the bolt, wherein portions of the fastener assembly include resistance-inducing threads;

 coupling an ultrasonic transducer with the bolt, for making ultrasonic load measurements in the fastener assembly;

25 electrically connecting an apparatus to the ultrasonic transducer for supplying signals to the ultrasonic transducer and for receiving signals from the ultrasonic transducer;

30 monitoring the signals received from the ultrasonic transducer, providing an accurate measurement indicative of the load in the fastener assembly; and

 adjusting the measurement indicative of the

load to compensate for effects of heating of the fastener assembly resulting from prevailing torque associated with the thread-locking fastener assembly.

30. The method of claim 29 which further includes
5 the step of imparting torque to the bolt and removing torque from the bolt in response to the measurement of the load in the fastener assembly.

31. The method of claim 29 which further includes
the step of determining a zero-load ultrasonic measurement,
10 using the measurement indicative of the load in the fastener assembly.

32. The method of claim 31 which further includes
the step of measuring a torque in conjunction with the
measurement indicative of the load in the fastener assembly
15 to determine the zero-load ultrasonic measurement.

33. The method of claim 31 which further includes
the step of measuring an angle of rotation of the fastener
in conjunction with the measurement indicative of the load
in the fastener assembly to determine the zero-load
20 ultrasonic measurement.

34. The method of claim 31 which further includes
the step of measuring time in conjunction with the
measurement indicative of the load in the fastener assembly
to determine the zero-load ultrasonic measurement.

25 35. The method of claim 31 which further includes
the step of taking measurements for determining the zero-load
ultrasonic measurement prior to inducing the load in the
fastener assembly.

36. The method of claim 31 which further includes

the step of taking measurements for determining the zero-load ultrasonic measurement while inducing the load in the fastener assembly.

5 37. The method of claim 29 which further includes the step of placing markings on the ultrasonic transducer corresponding to data associated with the fastener assembly.

38. The method of claim 37 which further includes the step of marking a bar code on the ultrasonic transducer.